BIOLOGICAL EVALUATION
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EVALUATION OF MOUNTAIN PINE BEETLE ACTIVITY ON THE BLACK HILLS NATIONAL FOREST

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ABSTRACT

Mountain pine beetle populations have been increasing in the Black Hills over the last 3 years. In 1999, 2000, and 2001, aerial surveys have detected a large mountain pine beetle infestation in the Beaver Park area on the Northern Hills Ranger District. Ground surveys found 46.2 trees per acre killed on average over the last 3 years, with approximately 58% of these trees being currently infested. Also, brood sampling continues to indicate that beetle populations are still increasing in the area. Three years ago nearly 70% of the forested land in the Beaver Park area was classified in the moderate to high stand susceptibility categories. Stand susceptibility is being reduced as much of the basal area has been decreased by beetle-caused tree mortality. However, because there has been no treatment, there continues to be epidemic mountain pine beetle populations and associated high levels of tree mortality in the Beaver Park area. In addition to the mountain pine beetle situation in Beaver Park, pockets of beetle-killed trees have been detected from aerial survey in the Bear Mountain, Steamboat Rock, and Deerfield areas. Ground surveys in these areas indicate an average of 16.4, 11.0, and 6.9 trees per acre killed over the last 3 years, respectively. About 65 % of these trees are currently infested over these three areas. Brood sampling in these areas suggest beetle populations are increasing.

Strategies for dealing with the mountain pine beetle include: do nothing, silvicultural treatments, sanitation/salvage harvesting, infested tree treatment and individual tree protection. Although the part of the Beaver Park area that has been classified as roadless is off limits to treatment, a full range of treatments should be considered in the surrounding areas to limit the continued expansion of the mountain pine beetle epidemic in this area. Similarly, a combination of silvicultural treatments and sanitation harvesting or mechanical treatment is recommended for the Bear Mountain, Deerfield, and Steamboat Rock areas.

INTRODUCTION

Mountain pine beetle (*Dendroctonus ponderosae*) is the number one insect killer of pines throughout the western United States. The beetle is a native species to the West and attacks most pine species including ponderosa pine in the Black Hills.

The mountain pine beetle has one generation per year in the Black Hills. Adult flight typically occurs in July - August, when adults leave previously infested trees and attack uninfested, green trees. The adults attack green trees, chew through the bark and construct galleries along which eggs are laid. Larvae hatch from the eggs and begin feeding on the phloem of the tree in late summer to early fall. Larvae, pupae or callow adults overwinter under the bark of the infested tree. In the spring, the beetle finishes its maturation process, producing the next generation of adults.

Populations of the mountain pine beetle are usually found at an endemic level, killing and reproducing in stressed or weakened trees, including lightning struck and root diseased trees. Less than one tree per acre per year killed is considered to be an endemic level. For reasons that are not fully understood, beetle populations can increase dramatically. In the increasing and epidemic stages, healthy trees are attacked and killed along with stressed trees. In 1999, areas of Beaver Park had tree mortality ranging between 83 trees per acre to 1 tree per acre killed over a three-year span (Allen and McMillin 1999). Populations in Beaver Park and other areas of the forest continued to increase in 2000 (Allen and McMillin 2000).

Mountain pine beetle has always been a part of the Black Hills forest ecosystem, with outbreaks occurring periodically. The first recorded outbreak in the Hills occurred from the late 1890's through the early 1900's and killed an estimated 1-2 billion board feet of timber. Outbreaks also have occurred in the 1930's, 1940's, 1960's and 1970's, each lasting 8-13 years with the 1970's outbreak being larger and causing more mortality than any of the others, except for the turn of the century outbreak. The most recent outbreak occurred from 1988-1992 in the Bearhouse Area on the Harney Ranger District and ended up killing over 50,000 trees (Pasek and Schaupp 1992). Outbreaks of the beetle can cause considerable changes in forested stands, including a reduction in average stand diameter and stand density (McCambridge et al. 1982). Tree mortality levels of 25% can be expected throughout the landscape surrounding outbreak areas and levels of up to 50% or more can occur in heavily attacked stands (McCambridge et al. 1982). Outbreaks can conflict with land management objectives: they reduce timber stocking levels, affect wildlife habitat, increase short term fire risks, and can negatively effect visual, old growth and recreation values (Samman and Logan 2000).

Susceptibility of pine stands to beetle attack can be categorized in the Black Hills. Generally stands are considered to be most susceptible when 75% of the stand is in the 7-13 inch diameter range and the stand density is over 120 feet of basal area per acre (Stevens et al. 1980, Schmid and Mata 1992). It should be noted that these are general hazard rating guidelines and most stand inventory data are based on stand averages; small pockets that have high stocking levels within a low density stand can be a focal point for beetle buildup. Stand hazard ratings give an indication of which stands are most likely to have initial beetle infestations. Once an outbreak has started, any stands containing suitable host material are likely to incur damage. These ratings also give no indication of local beetle pressure. However, hazard ratings can help to prioritize what stands can be treated to minimize beetle susceptibility. It also points out that the best approach to reducing losses to the mountain pine beetle for the long-term is forest management to reduce stocking densities. Decreases in stocking densities will lower the probability that beetle outbreaks will be initiated, but it is a continual process to keep stands in the low risk category. Recent work has shown that areas treated to 60 basal area can be expected to reach high hazard (120 basal area) again in about 25-50 years. Stands treated to 80 basal area can reach 120 basal area in 13-36 years, and stands treated to only 100 basal area will be back to 120 basal area in 9-16 years (Obedzinski et al. 1999). These timeframes of when a forest can increase in hazard level are relatively short, often shorter than the typical stand re-entry time interval.

Other forms of control of mountain pine beetle, such as natural enemies or environmentally related factors, are less predictable. Generally, when beetle populations reach outbreak proportions, natural enemies, such as birds and predaceous or parasitic insects, are not numerous enough to have a noticeable effect on the outbreak. Natural enemies are more important in limiting mountain pine beetle populations that are in the endemic phase (Bellows et al. 1998). Likewise, environmental factors cannot be counted on for lessening the outbreak. For example, temperatures of -10° F can kill beetles in October but temperatures of -25° are needed by February (Schmid et al. 1993). These temperatures need to be reached under the bark, in the phloem, as opposed to air temperatures. Beetles survive low temperatures by removing water from within their cells and replacing it with glycoproteins, which act as a type of anti-freeze (Bentz and Mullins 1999). This is a process known as cold hardening. Beetles have supercooling points, the temperature at which ice crystals start to form in body tissues, as low as -32° F in January (Bentz and Mullins 1999). Phloem temperatures become equal to air temperatures only when they persist for 24 hours or more (Schmid et al. 1993). Generally, phloem temperatures are found to be 5 to 10° F warmer than air temperature.

The focus of this evaluation is to examine the continuing beetle situation in the Black Hills National Forest. The evaluation is based on aerial survey information, ground surveys, and brood sampling data. Potential action alternatives and recommendations for different management areas are presented.

METHODS

The current mountain pine beetle conditions for the Beaver Park and other areas of the Black Hills National Forest were estimated using aerial survey and aerial photography data, brood sampling, and ground transects to estimate beetle caused mortality, including green currently infested trees, over the last three years. Stand hazard ratings for the Beaver Park area using the RIS database were reported in 1998 and were not repeated (Allen and McMillin 1998). It is assumed that with the extensive tree mortality that overall the number of stands in the high and moderate classes have decreased.

An aerial survey was conducted in September 2001. The number of fading trees and their approximate location are mapped in this survey. These surveys detect pines that have been killed in the last 1-2 years and whose crowns have faded. Currently infested trees, whose crowns have not faded, cannot be discerned from the air. Conditions such as those found in Beaver Park, with large spots and amounts of mortality, make this type of survey difficult to map precise estimates of tree mortality.

Beaver Park

Brood sampling was carried out in November 2001 according to methods described by Knight (1960). A 6 x 6-inch piece of bark was removed from the north and south sides of currently infested trees. All live and dead brood in the pieces were counted. Twenty trees were sampled at each of 3 sites in and around the Beaver Park area. The numbers of brood found were totaled for each area. The number of brood per sample is used in a regression equation to indicate whether beetle populations are decreasing, increasing or static.

Transect lines were run throughout the Beaver Park area in October 2001. Each transect line was approximately 1 mile long and 1 chain wide, covering an area of 8 acres per line (except where noted). Recently killed trees were tallied along each transect line. Attacked trees were broken into four categories: new beetle hits (year 2001 green attacked trees), one-year-old hits (2000), two-year-old hits (1999), and current pitchouts.

Twenty-one transect lines were run, covering 22.75 miles throughout the Beaver Park area, for a total of 182 acres evaluated. On each line, variable radius prism (BAF 10) plots were measured every ¼ mile. Diameter at breast height (DBH) was taken for all "in" trees in each plot. These measurements were used to provide an estimate of basal area (BA), DBH, and trees per acre (TPA) along the transect lines.

Bear Mountain

The 2001 aerial survey detected numerous pockets of tree mortality to the south and west of Bear Mountain. A total of 6 transects were completed, covering 9.25 miles (74 acres) throughout this area. The assessment included areas adjacent to FS293 (Bear Mountain Lookout and Sourdough Draw). Using the methods described above, brood sampling along the FS293 was conducted in November 2001.

Steamboat Rock

The area around Steamboat Rock was evaluated through ground surveys in 1997 through 1999 (Allen 1998, Allen and McMillin 1998, McMillin and Allen 1999). As a result of the beetle situation, and because there was a planned timber sale in the area, the district re-evaluated the sale area, changing volumes to be removed in a sanitation effort. Cutting and removal of infested trees was completed in June of 1998. This year's assessment covered much of the same ground as reported in Allen and McMillin (1998) and McMillin and Allen (1999). Nine transects were completed, covering 8.25 miles (66 acres) throughout this area. The assessment included areas south of Nemo Road adjacent to Steamboat Rock picnic grounds, FS147.1A, and FS149. Using the methods described above, brood sampling along FS147.1A was conducted in November 2001.

Deerfield Lake area

Ground surveys of campgrounds, day use, and surrounding areas were conducted in November of 2001 to determine the level of current beetle activity. In Whitetail and Dutchman Campgrounds, each campsite was visited along with about 60 feet into the forest surrounding each campground. Pockets of recently killed (1-year-old dead trees) and green, beetle infested trees were recorded. Also, unsuccessful attacks, or pitchouts, were noted. The surrounding areas, especially south and west of Deerfield Lake were also surveyed in the same fashion as mentioned above. Eighteen transects covering 16 miles (128 acres) were surveyed.

RESULTS

During the mid-1990's, beetle mortality was light and scattered throughout the Black Hills. In 1997, there was a noticeable increase in mortality detected. The 1999 survey showed another sharp increase from 1998, with much of the heaviest damage concentrated into a few areas. The aerial survey from 1999 detected a total of 25,562 trees killed throughout the Black Hills. This is an increase from the 10,726 trees killed on National Forest lands in 1998. In 2000, the amount of mortality increased again to 38,262 trees. In all cases, much of the damage was concentrated in groups of 25 trees or more in a few areas. More than 60% of the total tree mortality recorded in the 1999 and 2000 aerial surveys was found in the Beaver Park area. Other areas sustaining concentrated pockets of tree mortality included Bear Mountain, Steamboat Rock and areas west and south of Deerfield Lake. In 2001 there was a tremendous increase in the number of trees killed and the mortality is appearing throughout the forest, although areas with previous epidemic populations still have heavy concentrations of mortality. The Beaver Park area had about 100,000 trees killed in 2001.

Beaver Park

Results from brood sampling are shown in Figures 1,2, and 3. These figures represent brood developing from attacks that occurred in August 2001. In all cases, the data confirm that mountain pine beetle populations are still increasing exponentially in the Beaver Park area. Slight decreases in this year's brood are expected before beetle flight occurs in the summer of 2002; however, the level of decrease is unknown. Natural enemies and competition with woodborer larvae feeding on the same food resource can cause brood mortality. The amount of mortality caused by weather factors, for example cold temperatures, is expected to be negligible, as the samples were taken in mid-November after low temperature extremes had occurred earlier in the fall and very little larval mortality was noted.

Table 1 lists the number of beetle-killed trees found on all transects for the 2001 ground survey in the Beaver Park area. Mortality from 1999, 2000, and green infested trees show that there is an average of 46.2 trees per acre killed throughout this area. About half of the trees noted are currently infested, with the other half being one- and two-year-old hits. This value is similar to what was found last year (41 trees per acre killed) (Allen & McMillin 2000). Beetle populations were projected to increase about 2 fold from last year to this year in the Beaver Park area. The increase will be about the same again this year; approximately twice the number of dead trees will be present in 2002 as compared to 2001. The combination of increasing population and high number of trees being killed per acre characterize this area as being in an epidemic phase.

Table 2 lists the number of attacks by transect line in the Beaver Park area, and corresponding average basal area and diameter of trees along that line. Based on the 2001 aerial and ground surveys, the areas having the largest concentrations of beetles are located in Forbes, Beaver, and Bulldog Gulches. Forbes Gulch has reached a point where the central part of the gulch is almost completely void of live trees. In central Forbes Gulch this year, trees down to 3 and 4inch diameter at breast height were being mass attacked. These trees will not produce much brood, but there is going to be little left even as far as advanced regeneration goes in this area. Beaver Gulch is quickly become very similar to Forbes. Spots from Beaver are starting to coalesce with those in Forbes creating spots that are over 100 acres in size. In addition, moderately large pockets of infested trees, up to 100 trees, can be found scattered throughout the remaining area. Many of the areas, such as Vanocker Canyon, Kirk Hill and Elk Creek Canyon are outside of the roadless area proper, and are showing where the infestation is moving. Much of the roadless area has been killed off, and the infestation is now spreading outward. The average DBH ranged from 8.7 inches to 14.7 inches and the average basal area ranged from 80 to 174 square feet per acre. This combination of tree size and stand density provide suitably sized material for beetle infestation and are characterized as moderate to high beetle hazard. Additionally, having these conditions occur over such a large and contiguous area as in Beaver Park lends itself to the continuation of a large-scale beetle epidemic.

Predicting mountain pine beetle spread and cumulative mortality over the course of an outbreak is difficult to accomplish. The amount of tree mortality from our transect lines is conservative in that only mortality that has occurred in the last three years (1999, 2000, and 2001) was accounted for and the outbreak is by no means over. The outbreak is continuing to increase over the landscape. Obviously, there was some tree mortality in prior years that was not accounted for, and mortality is still increasing. Based on the last three years, however, the range of mortality on a transect line ranged from 4.5-100 % of the average trees per acre. The lower end of the range is in the areas farthest away from the core infestation in the center of the Beaver Park Roadless area with the high end being in the center of Forbes Gulch, where beetle activity has been the most intense over the last three years. The final impacts will not be known until the epidemic subsides.

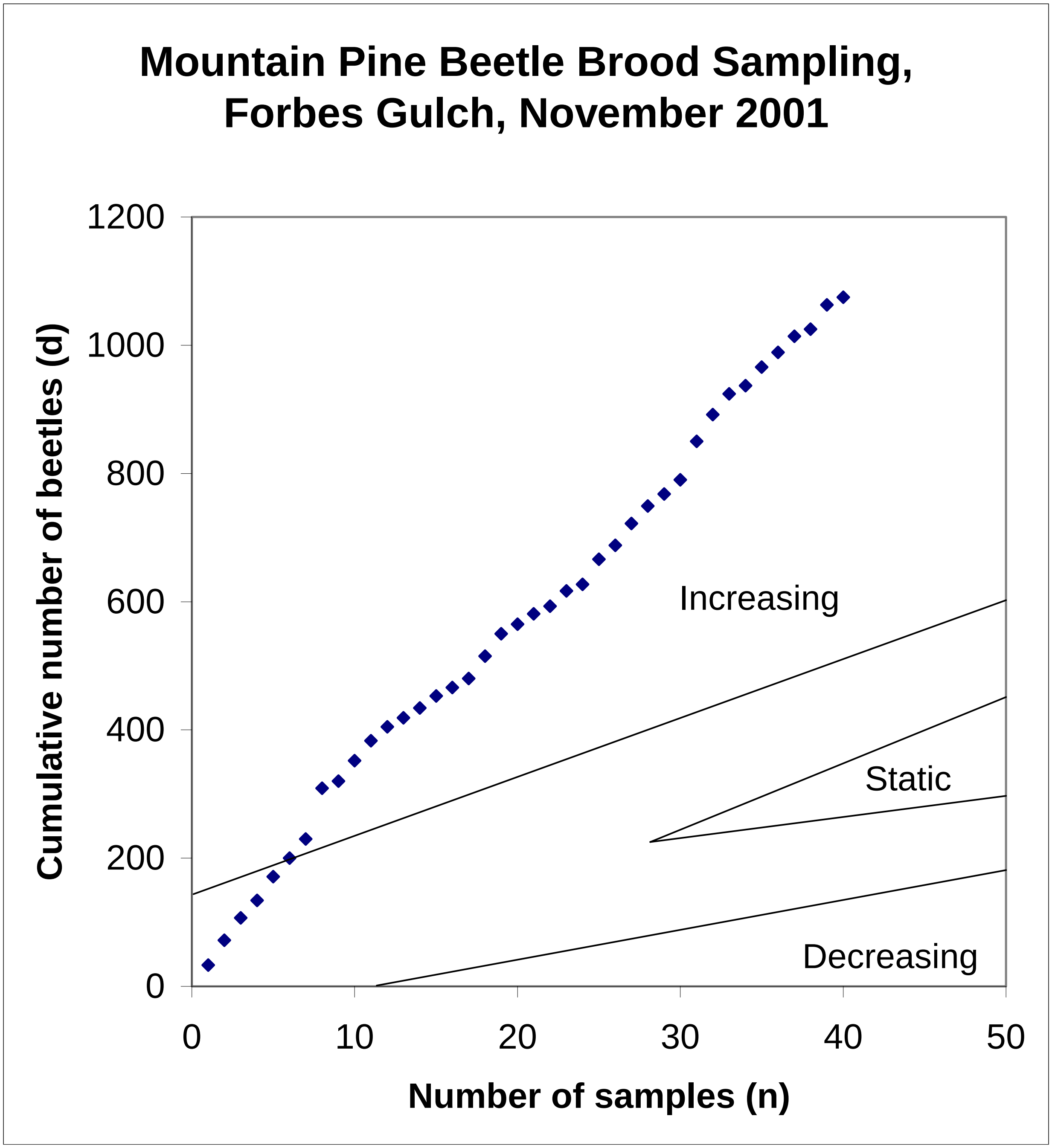

Figure 1. Sequential sampling of mountain pine beetle brood conducted in November 2001 from Forbes Gulch. Regression for the line is d= 40.9 + 51.2n.

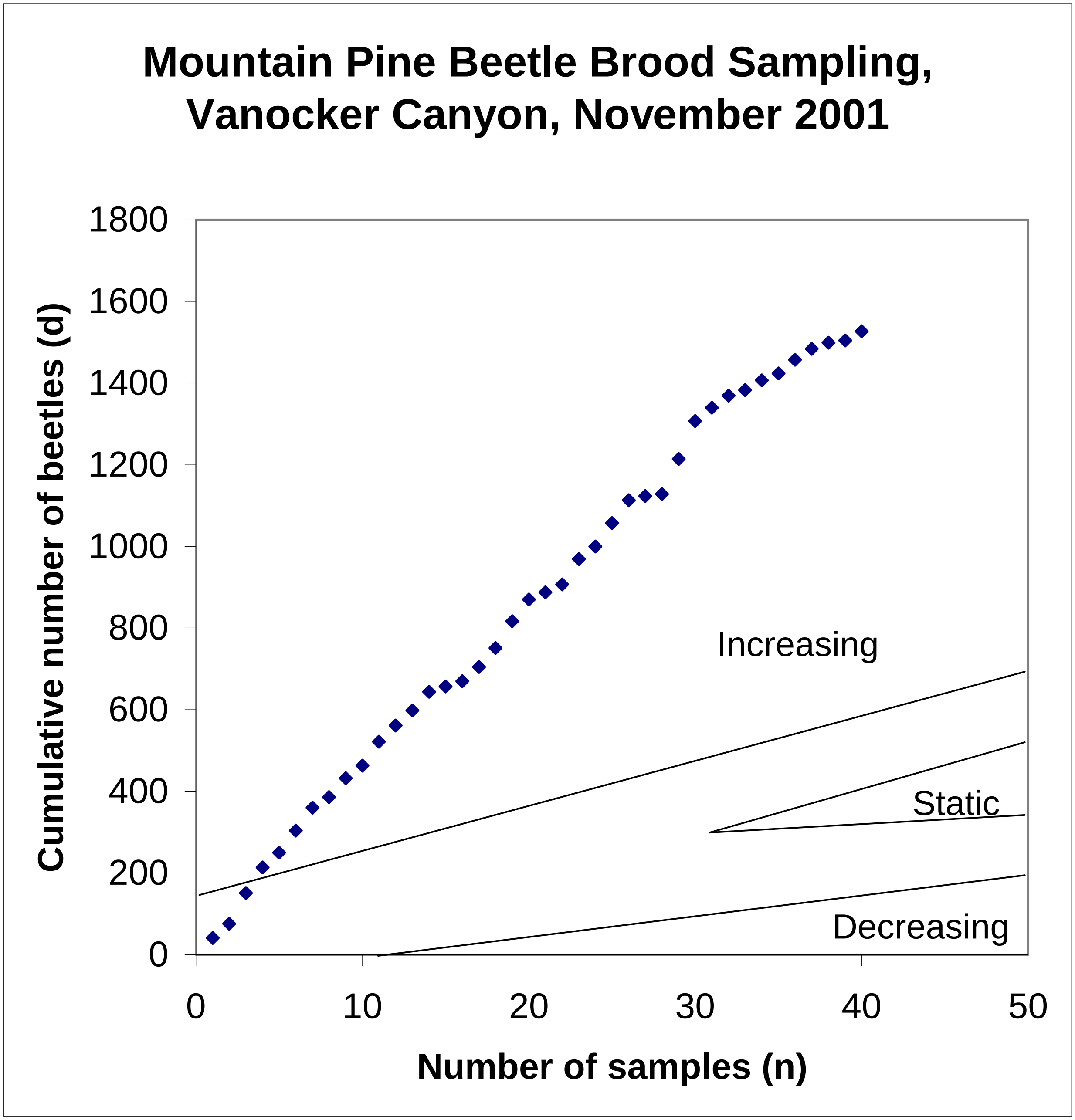

Figure 2. Sequential sampling of mountain pine beetle brood conducted in November 2001 at Vanocker Canyon. Regression for the line is d= 46.5 + 77.9n.

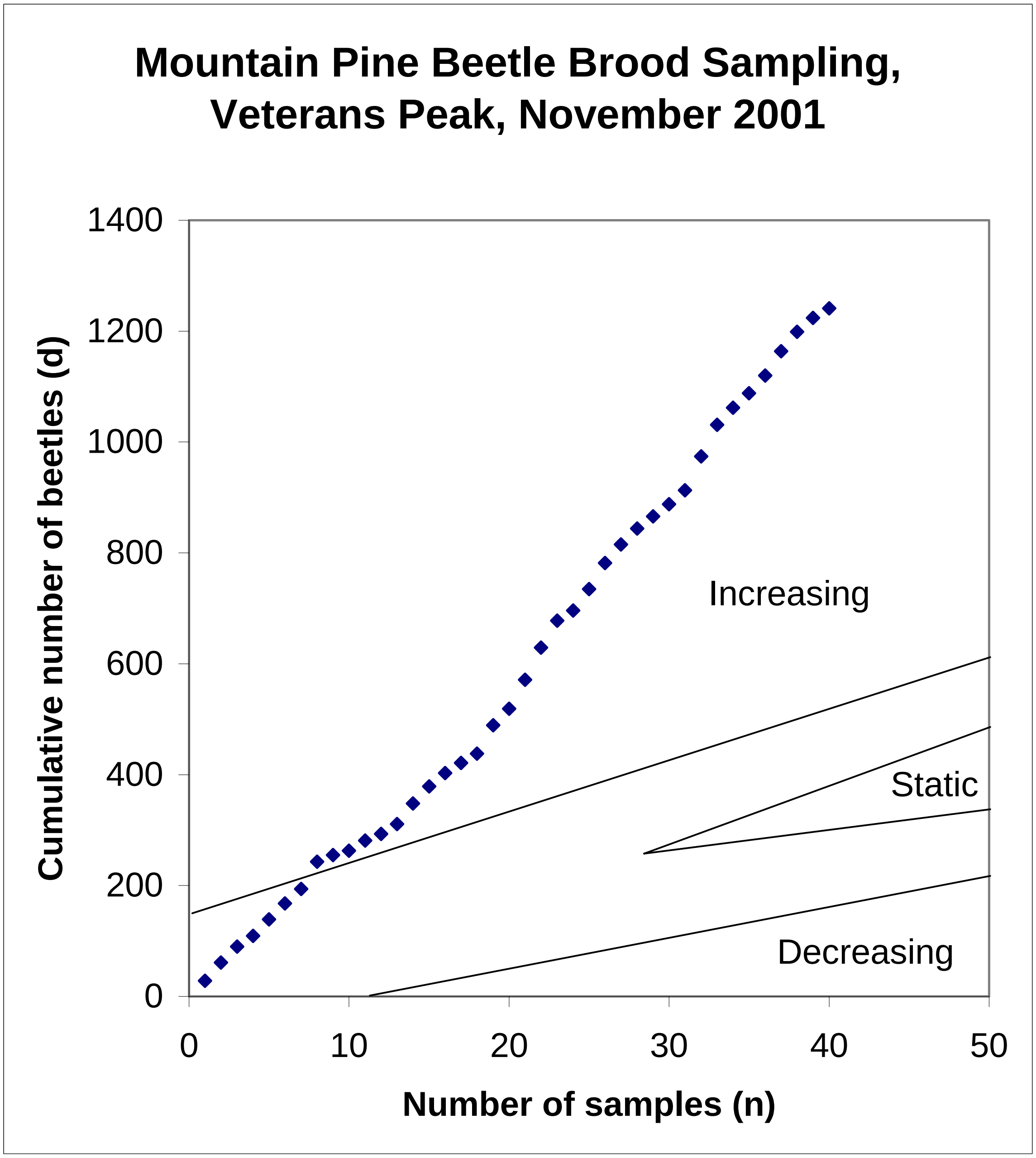

Figure 3. Sequential sampling of mountain pine beetle brood in November 2001 at Veterans Peak. Regression for the line is d= -72.5 + 63.9n.

Table 1. Number of mountain pine beetle attacked trees along 22.75 miles (182 acres) of transect lines in the Beaver Park Area, Northern Hills Ranger District, and the ratio of attack frequency between years.

	Number of Trees Attacked	
Year	Total Trees Attacked (182 acres)	Attacked Trees Per Acre
1999 Dead	615	3.4
2000 Dead	2862	15.7
Green Infested	4847	26.6
2001 Pitchouts	88	0.5
All Attacks 1999-2001	8324	46.2

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

1999:2000 -- 1:4.6

2000:2001 -- 1:1.7

1999:2001 -- 1:7.8

Table 2. Number of trees attacked per acre by mountain pine beetle along with average tree diameter, basal area, and trees per acre by transect line in the Beaver Park Area

Transect	CY	1yr	2yr	Mean BA	Mean DBH	TPA	Trees Killed/Acre	% TPA KILLED
1	8.6	3.3	0.2	157.5	11.1	224.4	12.1	5.4%
2	20.6	15.1	2.8	155.0	10.7	242.1	38.5	15.9%
3	33.3	19.7	3.0	145.0	13.7	136.3	56.0	41.1%
4	3.7	5.2	0.8	113.3	13.6	103.0	9.7	9.4%
5	15.8	18.9	7.5	140.0	11.0	200.8	42.1	21.0%
6	2.3	1.8	0.5	95.0	12.5	99.9	4.5	4.5%
7	8.4	2.1	0.4	142.5	11.9	175.2	10.9	6.2%
8	7.0	4.3	1.2	160.0	10.4	263.9	12.5	4.7%
9	26.1	13.6	5.6	153.8	9.7	275.5	45.3	16.5%
10	30.4	11.3	8.2	125.0	10.3	207.4	49.9	24.1%
11	19.3	10.2	5.1	125.0	9.9	217.7	34.6	15.9%
12	3.4	2.3	0.6	125.0	12.4	141.4	6.3	4.4%
13	20.8	14.3	1.2	175.0	9.5	339.5	36.3	10.7%
14	28.5	10.9	0.2	116.7	10.8	169.7	39.6	23.3%
15	13.9	2.5	3.6	92.5	14.7	73.7	20.0	27.2%
16	65.5	29.7	6.4	174.0	10.9	260.6	101.6	39.0%
17	89.8	100.3	8.2	133.3	11.2	186.1	198.3	106.6%
18	65.4	48.9	2.2	120.0	10.4	194.3	116.5	59.9%
19	9.3	7.8	5.3	80.0	12.7	86.8	22.4	25.8%
20	97.5	42.5	7.8	140.0	10.4	224.9	147.8	65.7%
21	42.0	3.7	0.6	130.0	8.7	297.1	46.3	15.6%

Bear Mountain
Although the overall total tree mortality was relatively low compared with Beaver Park, there was an increase in the number of trees killed per acre each of the last three years in the Bear Mountain area (Tables 3 and 4). Based on the more than 16.4 trees killed per acre over the last 3 years and that almost two thirds of this tree mortality was comprised of currently infested trees, mountain pine beetle is definitely increasing in this area. In addition, based on the average stand basal area and tree diameter, most of the area is dominated by highly susceptible stands. Brood sampling in this area also suggests that beetle populations are increasing (Figure 4). Less than 5 % of the brood in the sampling process had sustained mortality from cold temperatures.

Table 3. Number of trees attacked per acre by mountain pine beetle, basal area (BA), average tree diameter (DBH), and trees per acre (TPA) by transect near Bear Mountain, Black Hills National Forest.

Transect	CY	1yr	2yr	Mean BA	Mean DBH	TPA	Trees Killed/Acre	% TPA KILLED
1	11.5	4.7	0.5	123.1	10.2	214.2	16.7	7.8%
2	28.8	17.0	9.0	145.0	9.8	264.4	54.8	20.7%
3	11.2	0.6	0.6	140.0	10.7	219.9	12.5	5.7%
4	8.6	1.4	2.4	138.6	9.2	293.5	12.4	4.2%
5	8.9	3.7	0.6	130.0	11.1	184.1	13.2	7.2%
6	7.9	2.0	0.8	131.4	10.4	214.8	10.7	5.0%

Table 4. Number of mountain pine beetle attacked trees along 9.25 miles (74 acres) of transect lines in the Bear Mountain Area, Hell Canyon Ranger District, and the ratio of attack frequency between years.

	Number of Trees Attacked	
Year	Total Trees Attacked (74 acres)	Attacked Trees Per Acre
1999 Dead	105	1.4
2000 Dead	278	3.8
Green Infested	800	10.8
2001 Pitchouts	33	0.4
All Attacks 1999-2001	1216	16.4

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

1999:2000 -- 1:2.6

2000:2001 -- 1:2.8

1999:2001--1:7.6

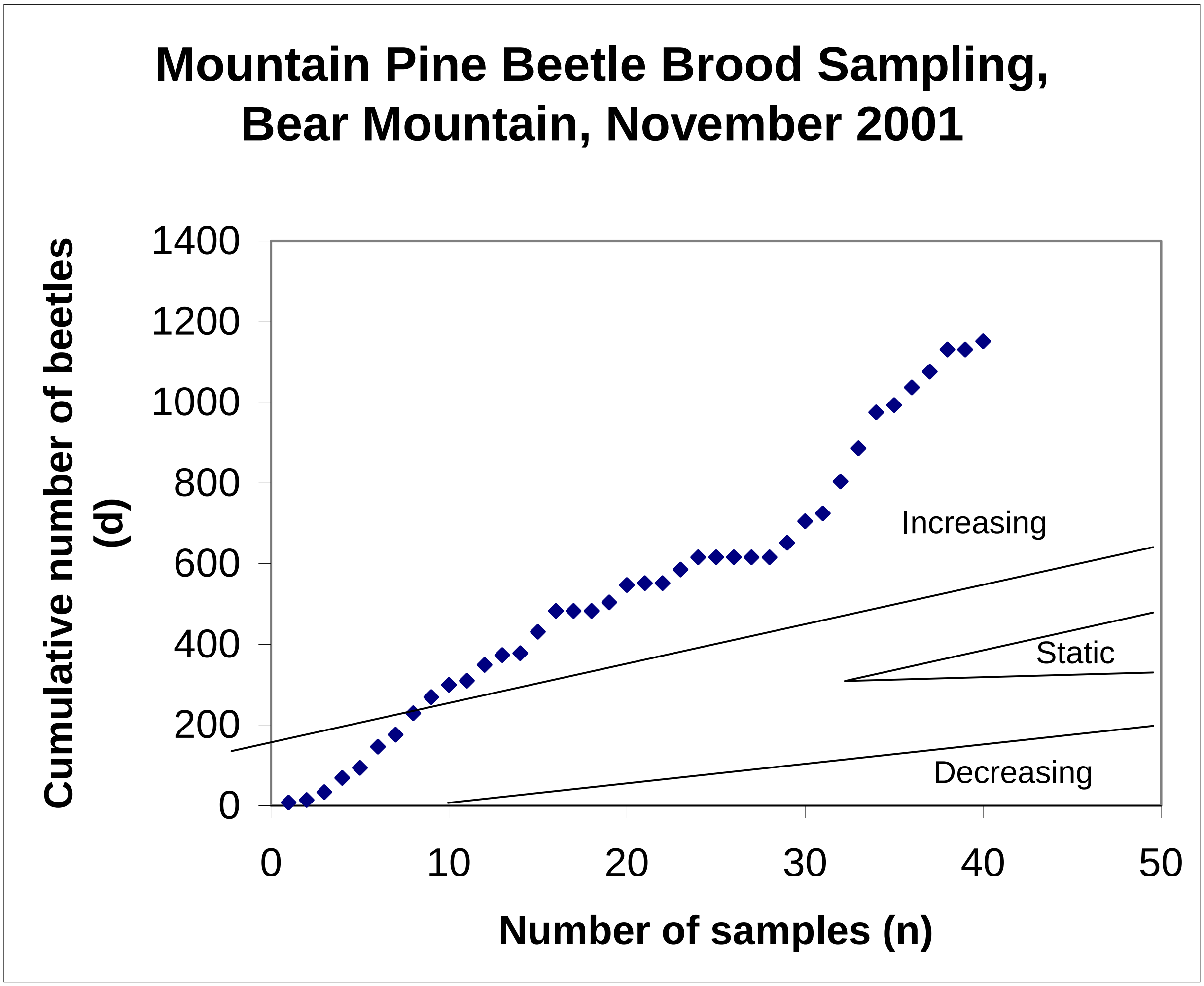

Figure 4. Sequential sampling of mountain pine beetle brood conducted in November 2001 at Bear Mountain. Regression for the line is d= -37.6 + 55.3n.

Steamboat Rock

The 2001 ground surveys within the Steamboat Rock area found areas with significant beetle activity and areas where activity has subsided (Tables 5 and 6). Areas south of the Nemo Road across from Steamboat Rock Picnic Ground and areas on the hills to the east of Nemo had some very significant beetle spots. Much of it was in the form of green hits (68%), indicating that these areas may have infestations for years to come. Also, in these areas, stand conditions are at a stage that is highly susceptible to sustaining beetle populations. In other areas, such as those that have been treated through thinning, sanitation and salvage in the past are generally have endemic beetle populations. Brood sampling near Nemo suggests that beetle populations are increasing in this area (Figure 5).

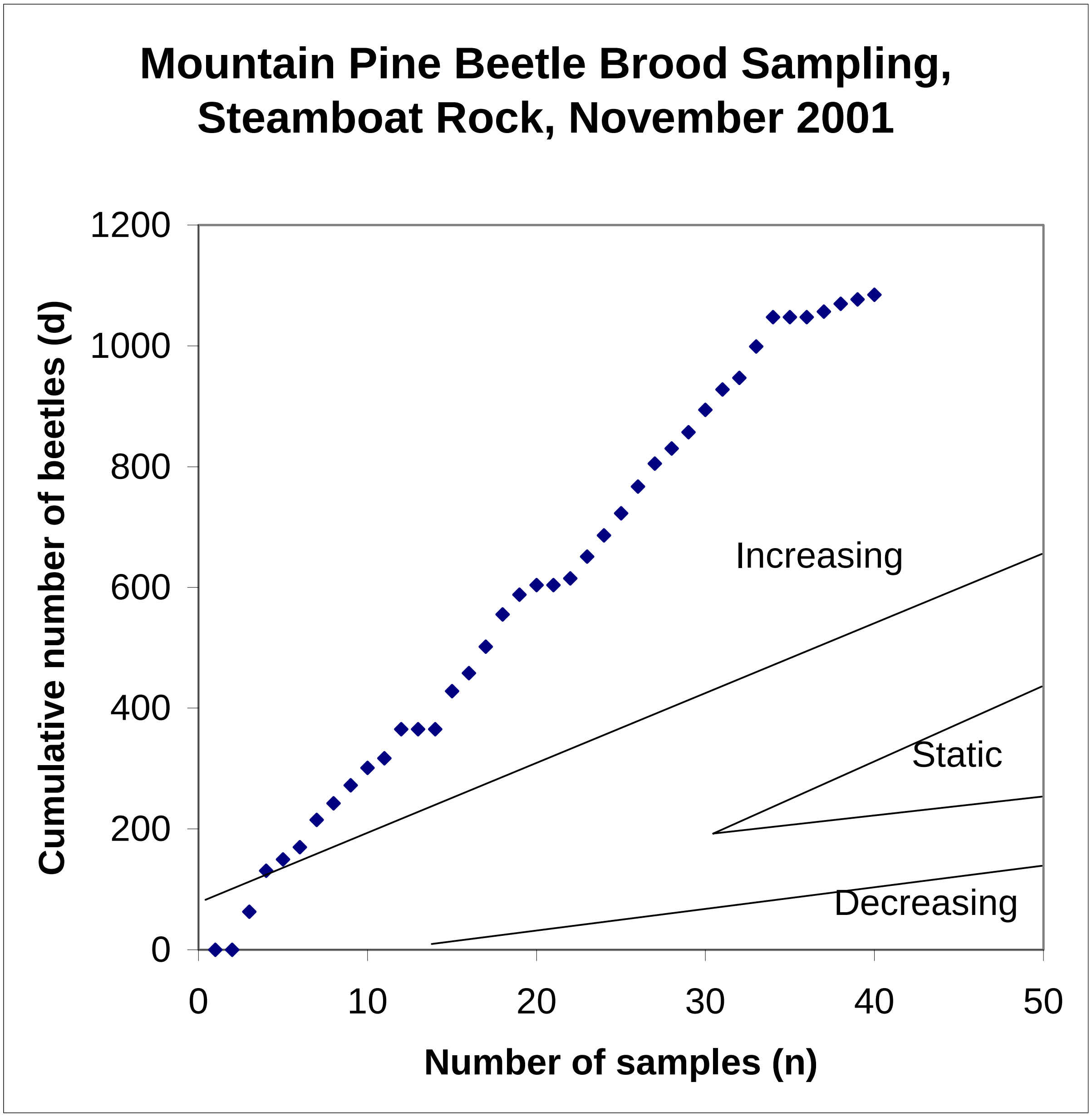

Figure 5. Sequential sampling of mountain pine beetle brood conducted in November 2001 at Steamboat Rock. Regression for the line is d= -17.7 + 58.4n.

Table 5. Number of mountain pine beetle attacked trees along 8.25 miles (64 acres) of transect lines in the Steamboat Rock Area, Northern Hills Ranger District, and the ratio of attack frequency between years.

	Number of Trees Attacked	
Year	Total Trees Attacked (64 acres)	Attacked Trees Per Acre
1999 Dead	113	1.8
2000 Dead	109	1.7
Green Infested	483	7.5
2001 Pitchouts	0	0.0
All Attacks 1999-2001	705	11.0

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

1999:2000 -- 1:1

2000:2001 -- 1:4.4

1999:2001--1:4.4

Table 6. Number of trees attacked per acre by mountain pine beetle, basal area (BA), average tree diameter (DBH), and trees per acre (TPA) by transect near Steamboat Rock area, Black Hills National Forest.

Transect	CY	1yr	2yr	BA	DBH	TPA	Trees Killed/Acre	% TPA KILLED
1	17.2	3.5	1.1	133.3	9.9	240.5	21.8	9.1%
2	4.9	0.7	0.9	112.5	9.6	212.0	6.5	3.1%
3	4.0	0.8	3.2	132.5	11.6	169.7	8.0	4.7%
4	0.6	0.1	0.4	152.5	10.7	232.2	1.1	0.5%
5	2.0	0.5	0.5	190.0	10.7	259.0	3.0	0.1%
6	6.7	1.7	2.6	116.7	12.0	136.7	11.0	8.0%
7	13.1	1.6	4.1	160.0	11.4	212.6	18.8	8.8%
8	7.1	4.3	1.0	120.0	11.1	163.6	12.4	7.6%
9	0.8	0.0	0.0	105.0	11.0	152.9	0.8	0.5%

Deerfield Area

Areas around Deerfield Reservoir showed a significant increase from previous years. The aerial survey noted widespread, though scattered, areas of mountain pine beetle activity this year. Much of this was in the form of single or small groups, but there were some larger groups of 50-100 trees noted. Ground surveys indicate that there are roughly 3 times as many currently infested green trees as opposed to trees killed in 2000 (Table 7). This indicates that the population in this area is certainly on the increase. Basal areas ranged from 70 to 175, with stands in the high end being very susceptible to continued beetle activity and there are already areas that have over 20 trees per acre killed indicating that the population has passed into the increasing stage (Table 8). Brood sampling done along Ditch Creek certainly indicates an increasing population (Figure 6). As is the case with the other places sampled for brood, all beetles were larvae and there was very little, to no weather caused mortality.

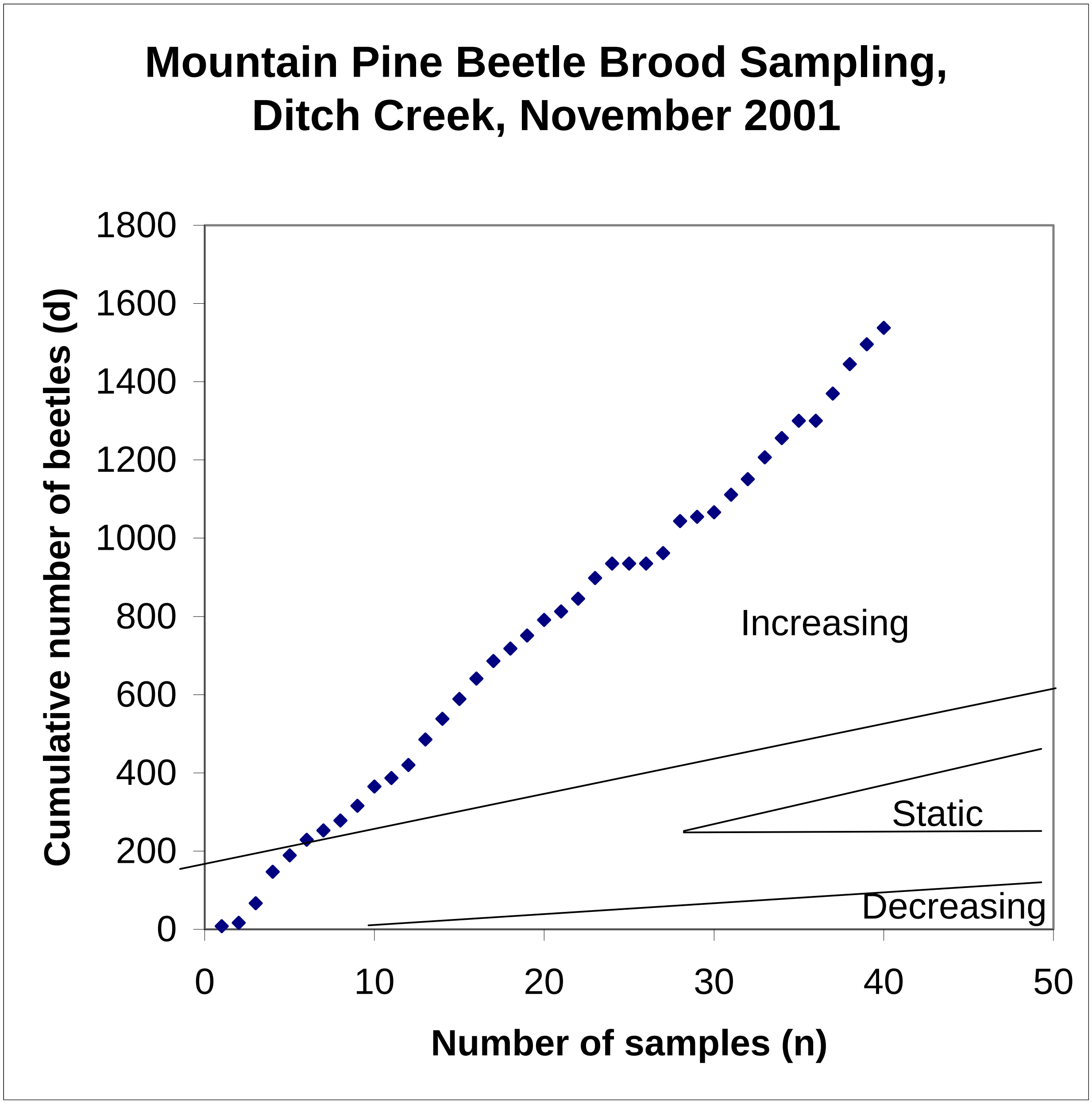

Figure 6. Sequential sampling of mountain pine beetle brood conducted in November 2001 at Ditch Creek. Regression for the line is d= -25.8 + 75.2n.

Table 7. Number of mountain pine beetle attacked trees along 16 miles (128 acres) of transect lines in the Deerfield Area, Mystic Ranger District, and the ratio of attack frequency between years.

	Number of Trees Attacked	
Year	Total Trees Attacked (128 acres)	Attacked Trees Per Acre
1999 Dead	83	0.6
2000 Dead	222	1.7
Green Infested	564	4.4
2001 Pitchouts	28	0.2
All Attacks 1999-2001	869	6.9

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

1999:2000 -- 1:2.8

2000:2001 -- 1:2.6

1999:2001 -- 1:7.3

Table 8. Number of trees attacked per acre by mountain pine beetle, basal area (BA), average tree diameter (DBH), and trees per acre (TPA) by transect near Deerfield area, Black Hills National Forest.

Transect	CY	1yr	2yr	BA	DBH	TPA	Trees Killed/Acre	% TPA KILLED
1	2.3	1.6	0.1	90.0	12.3	103.3	4.0	3.9%
2	2.2	1.0	0.0	70.0	12.9	74.0	3.2	4.3%
3	1.7	0.5	0.0	133.3	11.5	179.0	2.2	1.2%
4	4.3	0.7	0.2	133.3	13.0	128.3	5.2	4.0%
5	21.6	3.6	0.0	105.0	11.1	141.3	25.3	17.9%
6	0.6	2.3	0.5	115.0	10.2	193.0	3.4	1.7%
7	1.3	0.7	0.7	90.0	10.6	133.7	2.8	2.1%
8	8.2	4.0	3.0	126.7	12.0	149.6	15.2	10.1%
9	15.1	5.0	3.2	104.0	13.3	101.6	23.3	22.9%
10	0.7	0.7	0.0	108.8	13.1	110.3	1.4	1.3%
11	0.0	0.3	0.0	85.0	16.1	57.1	0.3	0.4%
12	4.5	0.3	0.2	110.0	8.8	233.6	5.0	2.1%
13	0.6	1.1	0.6	77.5	14.2	67.9	2.4	3.5%
14	3.8	3.7	0.7	84.0	11.6	109.2	8.2	7.5%
15	0.8	0.7	1.5	100.0	11.9	120.9	3.0	2.5%
16	3.5	0.8	0.1	165.0	11.3	218.4	4.4	2.0%
17	1.5	0.0	0.3	100.0	11.7	119.5	1.8	1.5%
18	0.0	0.0	0.0	175.0	9.9	323.5	0.0	0.0%

CONCLUSIONS

Beaver Park

The high number of trees killed per acre found in Beaver Park is approaching totals that are above and beyond those reported for previous outbreaks in the Black Hills. The number of trees per acre attacked in one year has been as high as 26.8 on the Spearfish District in the beetle epidemic of the 1970's (Creasap and Minnemeyer 1976) and 61.4 in the Bear Mountain/Whitehouse Gulch area in the early 1990's (Pasek and Schaupp 1992). The number of killed trees from certain areas within Beaver Park area is already above these reports, with highs of almost 200 trees per acre killed, and still climbing. At this point, entire hillsides have had their entire overstory destroyed. There are spots in Beaver Park where every tree had been killed and many of the trees within these spots are green infested trees that will produce beetles next summer. Year-to-year attack ratios of 1:2 or 1:3 are fairly common in population buildups. The overall attack ratio from 2000 to 2001 was 1:1.7; however, there were a number of places where that ratio was 4 or 5 to 1. Many of the places that have the largest expanding populations are now outside of the roadless area itself. Stand conditions in areas that have not been already decimated by beetles remain conducive to sustaining high levels of beetle caused mortality. The areas that are starting to decline in beetle infestation are those where most or all of the overstory has already been killed. All infested trees that were examined had live brood in them, mostly larvae. A general observation from the ground surveys was that there was some woodpecker activity, though it was very light and scattered, throughout the area. Woodpeckers are a natural enemy of the insects under the bark. Although woodpeckers typically forage for woodborer larvae that follow mountain pine beetle, they also eat some mountain pine beetle larvae. At this point it is unknown what percentage of the beetles will overwinter successfully; however, with the high number of new attacks there should be plenty of new beetles to continue to fuel outbreaks in 2002.

Mountain pine beetle has reached and sustained outbreak proportions in the Beaver Park area. Currently, there are extensive pockets of mortality and the population is still building. Dramatic changes on the landscape have already occurred and additional changes can be expected in the next few years as mortality continues to increase. Any of the areas surrounding Beaver Park that contain suitable host material are also at risk to sustaining losses over the next few years. How high the mortality level will reach is hard to predict; however, in lodgepole pine forests, mountain pine beetle has caused greater than 90% mortality in trees over 5 inches in diameter in uncut (generally greater than 120 basal area) stands (McGregor et al. 1987). Although it is a different tree species, this certainly describes stand conditions in much of the Beaver Park area. In ponderosa pine in the Black Hills, it was estimated that around 80% of susceptible trees had been killed in portions of the Bear Mountain area in the late 1980's and early 1990's (Pasek and Schaupp 1992). Again, stand conditions in this area were similar to those currently found in Beaver Park. McCambridge and others (1983) found that greater than 50% of heavily attacked stands of ponderosa pine were killed in Colorado. The final totals for mortality in the Beaver Park should equal or surpass the 50% level in moderate or high risk stands, and more than likely will approach the 80% level. There are already stands where the level of mortality has basically reached 100%. The question now becomes how large of a landscape will be affected to this level.

Bear Mountain

Mountain pine beetle is increasing in several areas around Bear Mountain. Stand conditions in this area will continue to support beetle populations in the next few years. Effects of this rising population can be expected to be similar to what occurred in the early 1990's in the Bear Mountain basin and possibly what is occurring now in Beaver Park (Pasek and Schaupp 1992). Much of the mortality around Bear Mountain is likely to be highly localized and concentrated as south and west of the mountain was burned in the Jasper fire and the north side of the mountain was either killed or thinned heavily during the early 1990's outbreak.

Steamboat Rock

Although beetle populations continue to be at endemic or static population levels adjacent to FS149, a large number of currently infested trees were recorded on both the south and north sides of Nemo Road in the vicinity of the Steamboat Rock picnic grounds. Populations also remain relatively high in the Erskine Gulch (FS147) area near Steamboat Rock and on the hillsides adjacent to Nemo. In many of these areas where populations are growing, there is plenty of stands in suitable condition to help continue to cause beetle expansion.

Deerfield

The areas surrounding Deerfield reservoir have seen probably the most notable increase over the last 2-3 years. Many of the other areas that have beetle populations of concern have been ongoing for a short time the Deerfield area showed a large increase this past year. There are already spots of 50-100 trees showing up and all indications are that the populations is increasing in this area.

ALTERNATIVES

There are a number of actions that can be used to reduce the impacts of mountain pine beetle in this area. These actions fall into two categories: direct action against the beetles themselves or indirect action that addresses the general stand conditions. Direct action deals with the symptoms, too many beetles in one place at one time, and is aimed at directly reducing the number of beetles present. Indirect action focuses on the cause of the problem, which relates to optimal stand conditions for beetle buildup and outbreak.

The only effective long-range strategy to minimize beetle-caused mortality is controlling stand conditions through silvicultural means over entire landscapes and constant monitoring for areas of beetle buildup.

Alternative 1: No Action. Accept that mountain pine beetle-caused tree mortality and the impacts associated with it as a natural process. The extent of the damage to the stands in this area and surrounding areas is difficult to estimate, but there will be changes in the forest caused by beetles. If stand conditions optimal for beetle outbreaks exist, the impacts can be expected to be similar to those described in the conclusion section.

Where to use: Use where other alternatives are not desired or cannot be used.

Advantages: There is no mechanical site disturbance. There will be an increase in the amount of light getting to the forest floor, so that understory species and regeneration may be enhanced. Habitat for some wildlife species may be enhanced by decreasing crown closure and creation of standing dead trees.

Disadvantages: This alternative allows beetle populations to increase and spread to other trees and surrounding areas. There is a loss in timber revenues from either not harvesting beetle-killed trees or letting the infestation grow and increasing the amount of killed timber. Fire hazards can increase with an increase in dead material, including red, dry needles. Visual and recreation values can be negatively affected. The loss of overstory tree cover can have a negative effect for some wildlife species. Regeneration can be impeded as dead trees fall and cover or shade the forest floor.

Alternative 2: Silvicultural Treatments. These are forest management actions that increase tree vigor and reduce stand susceptibility to beetle attack through reducing basal or controlling other stand conditions. They are preventative treatments that should be completed prior to stands experiencing beetle outbreaks. In the Black Hills, stands that are less than 80 square feet of basal area per acre with average stand diameters below 7 inches are at the lowest risk. When treating stands care must be taken to avoid leaving pockets of dense trees in an otherwise thinned stand.

Where to use: This is a preventative strategy and should be used regularly when planning timber harvests. It is not a tool in stands currently experiencing a beetle outbreak.

Advantages: Controlling stand conditions can reduce overall stand susceptibility to beetle infestation. It does not guarantee that beetle caused mortality will be eliminated; it creates conditions that are less likely to experience a beetle outbreak. It maximizes the economic return from timber sales, as cutting is done prior to mortality taking place. Although the forest will experience mortality through time, treating stands silviculturally allows the decisions on what the forest will look like in the future through the types of harvesting done. If not, the beetles will decide what the forest will look like in the future through their actions, and this may be considerably different than management goals.

Disadvantages: This action is not suitable for areas where timber harvest is not feasible. There is the site disturbances associated with timber harvest while the cutting is being done.

Alternative 3: Sanitation/Salvage Harvest. Sanitation harvesting involves removing currently infested pines prior to the beetle maturation and emergence. It requires the removal of green trees that have live brood in them. These green trees are already dead, however, the foliage will not change color until the following summer. Trees removed in a sanitation harvest are treated; either moved to at least one mile from the nearest live host type or processed at the mill, prior to beetle emergence. Salvage harvest involves the removal of beetle-killed trees that do not have live beetles in them. These trees have already changed color; their needles are either red or gone.

A relatively new approach to the sanitation of bark beetles includes the use of semiochemicals (e.g., pheromones produced by the beetles for aggregation or anti-aggregation behavior). One method that is used in combination with traditional sanitation practices involves baiting trees with aggregation pheromones in concentrated areas or on a grid system just prior to the adult flight period. After the trees are infested, the trees **must** be removed and treated as stated above. A spillover effect (i.e., trees adjacent to the baited trees are also attacked) is commonly experienced when using this technique, and these neighboring trees also must be removed and processed if attacked. The amount of spillover depends on the local population level of beetles.

Where to use: Stands susceptible to mountain pine beetle that are currently under attack where it is desirable to reduce mountain pine beetle populations and recover timber resource value. Also appropriate where beetle populations threaten currently uninfested nearby stands.

Advantages: Mountain pine beetle populations can be reduced in localized areas and in individual stands by removing most of the currently infested trees. This can provide some protection to surrounding uninfested trees and stands by removing a large source of attacking beetles. Timber values are recovered that would otherwise be lost or degraded. Fuel loading and fire hazard can be reduced by removal of much of the dead needles and timber. Regeneration can be enhanced through overstory removal and site disturbance.

Disadvantages: This alternative has a short implementation time. Areas must be marked and cut prior to beetle flight, i.e., before the end of June. Sanitation will not be effective on a large scale. It is only effective at suppressing beetles at the stand level and so will not work on a landscape level or when there is a chance of beetles re-infesting the treated area. Site disturbance that accompanies timber harvest occurs.

Alternative 4: Infested Tree Treatment. Cut and individually treat infested trees prior to beetle emergence. The action should kill most or all of the beetles within the cut trees. Examples of treatments include: cut and burn on site, cut and bury at least 6 inches on site, cut and chip, cut and debark. The use of beetle aggregation pheromones could be used in conjunction with this option to contain beetle spots to be treated.

> Where to use: This is most appropriate for treating small spots in areas where high value resources are nearby. It can be used in areas that are unroaded or too steep for conventional sanitation or salvage harvesting.

Advantages: Beetle populations can be reduced or eliminated from the treated area. This can provide some relief to surrounding uninfested stands and trees. The site disturbance is less than in conventional harvesting operations. Regeneration can be enhanced through the removal of overstory trees. Fire hazard can be reduced.

Disadvantages: The implementation time for this alternative is short. Treatments must be done after new infested trees are located and prior to beetle flight. This treatment only reduces beetle pressure in a small area; it is not effective on a landscape scale. This treatment does nothing to address stand conditions that led to beetle buildup in the first place.

Alternative 5: Protection of High Value Trees. Prior to beetle emergence in the summer, the stems of high value uninfested trees are treated with a registered insecticide.

> Where to use: On trees around residences, in campgrounds, or other high value areas. Trees must be of significantly high value and be under heavy beetle pressure to justify treatment costs.

Advantages: This action is very effective at protecting individual trees from becoming infested.

Disadvantages: Insecticide application does not effectively reduce beetle populations or address the cause of the outbreak. It does not guarantee protection; application must be thorough for it to be effective. Many people have concerns regarding environmental contamination when using pesticides. It is extremely expensive on a large scale and, therefore, is only appropriate for a single or a few high value trees.

RECOMMENDATION

Beaver Park

All alternatives are recommended depending on the site and suitability. The beetle population has risen to a point where any and all actions should be considered in the areas surrounding the roadless area.   Populations are spreading to adjacent areas at this point and will continue to expand and cause mortality in surrounding areas.

The do nothing alternative may be chosen out of necessity in some of the most remote areas and those with steeper slopes. This alternative would allow continued beetle buildup and its associated mortality. This mortality may be extensive in some areas that go untreated.

Alternative 2, silvicultural treatments (i.e., reducing basal area through thinning), is best used during long range planning processes. Stands in this area that can be manipulated need to have this done on a regularly scheduled basis to avoid future outbreaks. At this point, most of the silvicultural planning for the core of this area is too late. This would be most useful in nearby surrounding stands around the perimeter.

Alternative 3, sanitation and salvage logging, is highly recommended in those areas where it is possible. Removal of beetle-infested trees would need to be carried out in a short time frame, before the middle of July 2002 when the beetles would start to fly. At the very least, these types of operations ought to be carried out around the perimeter of the infested area where beetle populations exist in an effort to confine the outbreak in the Beaver Park area. In some of the gulches within this area, sanitation/salvage logging may be difficult and would likely result in some areas that are essentially clearcut because nearly every tree has been killed in the last few years or is currently infested.

Use of infested tree treatments should be considered, especially in high profile areas. These treatments can be used to kill overwintering beetles, thereby reducing the emerging beetle population to some extent. This alternative is not appropriate over the entire Beaver Park area, but could be useful in localized spots. Consideration should be given to using mountain pine beetle pheromones in conjunction with these treatments.

The use of protective sprays should be used only in very high value areas. These sprays could also be used in conjunction with aggregation pheromones, although this would only be on an experimental basis.

If there are no treatments carried out in this area, beetle populations will continue to grow and mortality will increase. The extent of damage that will occur and how long it will continue are difficult to state at this point in time; however, stands that are in close proximity to this area will remain at risk. The forest in the core of the Beaver Park area has already been significantly affected and changed, and there is a good likelihood that this epidemic will continue to expand and cause similar damage in surrounding areas.

Bear Mountain area
Alternatives 2, 3 and 4 are recommended depending on the management focus of different stands. Beetle populations continue to increase in this area and favorable stand conditions. Therefore, the potential for significant tree mortality to occur in this area exists over the next few years. Addressing the situation now, when it is still at stage where there is a high likelihood of minimizing mortality would be appropriate.

Steamboat Rock
The sanitation/salvage activities completed in 1998, in combination with commercial thinning, seem to have reduced beetle populations throughout much of this area. Continued sanitation should be done to reduce beetle populations further and protect the remaining stands. Areas of special concern include stands west of Erskine Gulch along FS144.1A, and along Nemo Road near the Steamboat Rock picnic ground. The area west of Erskine Gulch contains many stands having high basal areas and a building population of beetles. A combination of alternatives 2 (thinning), 3 (sanitation), and 4 (infested tree treatment) would be appropriate in this area. Some of the areas are designated as old growth or wildlife emphasis, and treatments can be customized to fit the stand objectives while minimizing mortality.

Deerfield Lake area
Annual monitoring of campgrounds, day use lands, and surrounding areas will be needed over the next few years in the face of beetle population increase throughout this portion of the Black Hills. In addition, due to what seems to be a rapidly expanding beetle population in the general forest, actions should be taken as soon as possible to minimize expansion until a landscape scale treatment recommendation can be reached. Using a combination of alternatives 2, 3, 4, and 5 may be warranted depending on site and suitability.

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